

The Tree-ferns of the genus Cyathea in Borneo

by

R. E. HOLTTUM

Royal Botanic Gardens, Kew

The most complete taxonomic account of the tree-ferns of Borneo is contained in Flora Malesiana, Series II (Pteridophyta) vol. 1, part 2 (1963), which covers the whole of Malesia and includes descriptions of 191 species. For identification of the 29 species of Borneo therefore it is necessary to use elaborate keys which were designed to cover a much wider range of species. The present paper is based on the work of 1963, since which little new information has been obtained, but the keys are revised and simplified to facilitate identification of Bornean species. Some additional information about local distribution is also given.

The present paper is written in the hope that it may help people who have the opportunity of making new observations on these plants. The descriptions are a summary of the characters of specimens seen by me, and anyone studying them in comparison with living plants will find gaps in the information here provided. I hope that some local naturalists will be able to take up this study, and I will do my best to help any such persons who will communicate with me. In particular, it is desirable that the keys to species should be revised, to include more characters which are easily observable in the field; many characters in the present keys can only be seen by careful use of a hand lens. Such a new key would help other local naturalists, and perhaps help to ensure that all species of this very interesting group of ferns are allowed to persist, in spite of increasing destruction of natural forest.

Almost all the species occur within the Mount Kinabalu National Park in Sabah or in neighbouring lowland forest, so that the present account covers the special needs of field botanists in the national park. Six* species are only known from Mt Kinabalu: *C. longipes*, *C. acanthophora*, *C. havilandii*, *C. stipitipinnula*, *C. discophora* and *C. megalosora*.

Cyathea plants may be recognized in nearly all cases by the presence of a trunk bearing moderately to very large bipinnate fronds which bear scales at the bases of their stipes (petioles). There is one tree-fern of the genus *Dicksonia* (*D. mollis* Holtt.) in forest on Mt Kinabalu at 5000-6500 ft; it has dense reddish hairs on its stipes, not scales, and sori in marginal pouches. Four species of *Cyathea* in Borneo have simply pinnate fronds and at most very short trunks; their indusia, if present, identify them generically, also their scales on stipe-bases which have minute oblique dark marginal setae.

Diagnostic characters for recognition of species

The most important characters for the main subdivision of the genus are found in the large scales at the bases of stipes. These are best seen on young fronds; old ones may lose most of them. When collecting herbarium specimens,

* The seventh, *C. brachyphylla* Holttum sp. nov. is described in the Addendum.

one can cut off a thin strip 5–10 cm long from the scale-bearing surface of the stipe; this is much more easily dried than a whole stipe. An additional character shown by the stipe is the distribution and shape of the areas, on each side of the stipe, where aerating tissue comes to the surface (called pneumathodes, or linear aerophores). These areas are almost white, and their surface is broken when old; they usually form a discontinuous line on each side of the stipe, or sometimes a double line. When whole stipes are dried, they shrivel along these lines, so that the shape and distribution of pneumathodes cannot be seen in most herbarium specimens, and in most cases information about them has not been recorded. A thin strip cut along the side of the stipe, to include several pneumathodes, is easily dried and provides permanent information in the herbarium.

The length of the stipe and size of the lowest pinnae may be important. In some species (e.g. *C. loheri*) the stipe is very short and the lower pinnae are gradually smaller, the lowest quite short. In two Bornean species there are very small pinnae at the base of the stipe, and then a long gap to the large pinnae; these basal pinnae should be looked for.

The other characters are best shown by the largest middle pinnae of a frond. Except in the simply pinnate fronds of a few species, these middle pinnae carry pinnules of almost uniform size for the greater part of their length; it is these pinnules which are described in the detailed descriptions of species, and their size, shape, depth of lobing and venation are important. On the upper surface of pinna-rachises and costae of pinnules there are always short curved hairs, but the occurrence and character of hairs and scales on the *lower* surface are much more varied and must be observed carefully; they may be seen in sufficient detail with a hand lens of 10 X magnification. These scales and hairs are in all cases mentioned in the present paper.

Sori are also important diagnostically, and have indusia of various shapes, or sometimes no indusia. Some indusia are very small and can only be seen by carefully removing the sporangia. The hairs which occur among the sporangia (paraphyses) are sometimes distinctive. In one Bornean species (*C. tripinnata*) there are false indusia formed by overlapping separate scales; these are not easy to see with a hand lens, but fortunately the species is easy to recognize from the fully tripinnate fronds which occur in no other species.

Classification

The classification here adopted is that of Flora Malesiana, with a change of subgeneric name which must be explained. In Flora Malesiana I divided the genus *Cyathea* into two subgenera, subg. *Cyathea* and subg. *Sphaeropteris*. The type species of *Cyathea*, *C. arborea* (L.) Sm., is native in the West Indies; I regarded the Malesian species placed in subg. *Cyathea* as closely related to it. But Dr R. M. Tryon subsequently made a new study of tropical American tree-ferns (Contr. Gray Herb. no. CC, 1970) and showed that *C. arborea* and some related species have stipe-scales of a distinct type not found in any species of the Old World. Dr Tryon also considered that subg. *Sphaeropteris* is sufficiently distinct to rank as a separate genus (there are a few species in tropical America). Thus he needed a new generic name for the Malesian species of *Cyathea* subg. *Cyathea* of my treatment, and the oldest available name is *Alsophila* R. Br. (type species *A. australis* R. Br. of Australia). He transferred all Malesian species of *Cyathea* subg. *Cyathea* to the genus *Alsophila*, and all in subg. *Sphaeropteris* to the genus *Sphaeropteris*. But in my view the differences are hardly of generic rank; this

is supported by the fact that species of both subgenera have the peculiar chromosome number 69. Therefore I retain the genus *Cyathea* for Malesian species, substituting subg. *Alsophila* for subg. *Cyathea*; the name subg. *Cyathea* should then be restricted to the tropical American species related to *C. arborea*.

A further note on the generic name *Alsophila* is desirable because it was used in the past in a quite different sense. The type species *A. australis* has no indusia, and in the 19th century this was regarded as the prime distinguishing character of the genus, which thus was made to include all then known species of *Cyathea* (in the sense of the present paper) which had no indusia. But Copeland pointed out (Philip. Journ. Sci. 3C: 353; 1909) that such a definition brings together species which are not allied; in the classification of the present paper it will be seen that exindusiate species occur in both subg. *Alsophila* and in subg. *Sphaeropteris*, and in each case the exindusiate species certainly conform in all other characters to their own subgenus. The genus *Alsophila*, as defined by Tryon, includes species with and without indusia; thus it has a significance quite different from that given to it by 19th century pteridologists (e.g. Beddome in his Handbook to the Ferns of British India, 1883).

Prior to Flora Malesiana, the most important publication on the ferns of Mt Kinabalu was in Gardens Bulletin S. S. vol. 7 (1934) 191—324, in which Carl Christensen gave an annotated list, based on all known collections including those made by J. C. and M. S. Clemens in 1931-32 and my own of 1931, which together doubled the number of species known from the mountain, and included reference to a few from other parts of Borneo. The paper includes an account of my itinerary, with notes on ferns seen (pp. 185—206). The number of species of *Cyathea* in that paper was 18. In some cases the nomenclature of the present paper differs from that of Christensen of 1934; references are given to all such cases.

When preparing my account of *Cyathea* for Flora Malesiana I examined type specimens of all previously published species, few of which had been described in sufficient detail for clear recognition, with the result that all comparative taxonomic statements were in some measure confused. I found for example that no two accounts of the species of *Cyathea* in the Nature Reserve adjacent to the mountain garden at Tjibodas in Java agreed as to number of species and distinction between them, though this forest had been studied more carefully than any other area in Malesia. This was due to the fact that scales on pinnules, and indusia, had not been examined in sufficient detail. When re-describing type specimens I discovered that many Malesian species had received more than one name, so that many earlier names appear as synonyms in Flora Malesiana. I have not cited all these synonyms, except those used by Christensen in 1934, nor have I cited previous descriptions of the species, which are mostly inadequate where they are not also inaccurate; they are not reliable as indicators of distribution of species. I have also not included Dr Tryon's new names, which may all be found in his publication cited above. References to the account of *Cyathea* in Flora Malesiana, Series II, vol. 1 (1963), are given as F.M. with page number.

KEY TO THE SUBGENERA AND SECTIONS

Stipe-scales usually dark and rigid, always with fragile edges which are eroded when old and may or may not bear irregular dark setae; hairs on lower surfaces, if present, crisped and appressed; indusia in some cases attached only on side of sorus remote from edge of pinnule-segment
..... subg. *Alsophila*

Indusia present (sometimes very small, hidden by sorus); rachises usually green when fresh, never dark chocolate-brown; fertile and sterile pinnules of almost uniform size sect. *Alsophila*
 Indusia absent; rachises dark chocolate-brown; fertile pinnules usually narrower, or with narrower lobes, than sterile Sect. *Gymnosphaera*

Stipe-scales usually thinner and paler, of uniform texture, with very short (usually darker) setae set obliquely on their edges; hairs on lower surface, if present, stiff and spreading erect from surface; indusia completely covering sorus and breaking at maturity, or lacking (in a few cases imperfect as an irregular ring round base of sorus), never attached on one side
 Subg. *Sphaeropteris*

Pinnules commonly 10–15 cm long, lobed almost to costa throughout or fully pinnate; costules not over 4 mm apart on pinnules 10 cm long; basal basiscopic vein of each group arising from costule above its base.....
 Sect. *Sphaeropteris*

Free tertiary leaflets few, sori indusiate or not, never covered by overlapping scales subsect. *Sphaeropteris*

Free tertiary leaflets present on all pinnules; sori covered by overlapping scales which simulate an indusium subsect. *Fourniera*

Pinnules rarely to 10 cm long, lobed less deeply, or pinnae undivided; costules usually 4 mm or more apart; basal basiscopic vein of each group arising from costa near base of costule Sect. *Schizocaena*

SUBG. *Alsophila* SECT. *Alsophila*

1. Stipe conspicuously spiny in basal part, spines 4–5 mm long:
 2. Pinnules all stalked except distal ones 1. *C. longipes*
 2. Pinnules not stalked, ± jointed to rachis 2. *C. acanthophora*
1. Stipe ± warty at base, lacking slender spines:
 3. Lower surface of costae densely and persistently scaly; indusium conspicuous, covering sorus to maturity:
 4. Pinnules commonly to $2\frac{1}{2}$ cm long; pinna-rachis densely scaly 3. *C. havilandii*
 4. Pinnules commonly to $7\frac{1}{2}$ cm or more long; pinna-rachis glabrescent:
 - 5.* Stipe 50 cm or more long; basal pinnae not greatly reduced 4. *C. oosora*
 - 5.* Stipe much shorter; lower pinnae gradually reduced, lowest c. 7 cm long 5. *C. loheri*
 3. Lower surface of costae not densely scaly; indusium small, at maturity reflexed against costule or covered by sorus:
 6. Pinnules commonly more than 2 cm wide, with wide sinuses between lobes 6. *C. incisoserrata*
 6. Pinnules less than 2 cm wide, sinuses between lobes narrow:

* See modification in Addendum, p. 181.

7. Indusium reflexed against costule and usually visible at maturity of sorus; paraphyses short 7. *C. borneensis*
 7. Indusium very small, covered by mature sorus; paraphyses longer than sporangia, 2–4 cells wide at base 8. *C. latebrosa*.

1. **Cyathea longipes** Copel., Philip. Journ. Sci. 12C(1917) 54. Gard. Bull. S. S. 7(1934) 205, 222. F.M. 98.

Stipe slender, to 200 cm long, dark and copiously spiny near base, spines to 5 mm long; basal scales early caducous, rather broad (they need further examination). Pinnae to at least 70 cm long; pinnules all stalked except distal ones, stalks of lowest on lower pinnae 10 mm long, on smaller pinnae 3–6 mm; largest pinnules 10–13 × 2.0–3.2 cm, acuminate, 1–2 pairs basal segments free or connected by a narrow wing along costa; rest of pinnule lobed almost to costa, lobes crenate, costules 4½–6 mm apart; veins to 10 pairs. Sori near costules; indusium rather thin, covering young sori, breaking irregularly at maturity. Main rachis and pinna-rachises green, lacking scales beneath, with scattered short spines; scales on lower surface of costae ovate-acuminate, thin, entire, brown, distal ones shorter and ± bullate; bullate acuminate scales on costules.

Only known from Mt Kinabalu; formerly abundant in ridge forest on Penibukan and Marei-Parei ridge, at 4000–5500 ft.

2. **Cyathea acanthophora** Holtt., Kew Bull. 16(1962) 51. F.M. 93.

Similar to *C. longipes* in spines on stipe, and in scales and sori, differing as follows: stipe to 80 cm long; basal scales to 20 × 1 mm (only seen on a young frond); pinnules not stalked, more or less jointed to pinna-rachis, smaller (8½–10 cm × 1.5–1.8 cm), without free basal segments.

Only known from Mt Kinabalu, on the Kamborangah ridge, at 6000–7000 ft.

3. **Cyathea havilandii** Baker, Trans. Linn. Soc. II Bot. 4(1894) 249. Gard. Bull. S. S. 7(1934) 202, 221. F.M. 96.

Trunk short; fronds mostly almost erect, to 100 cm long, densely scaly throughout. Stipe 30–40 cm; scales near base to 15 × 1–2 mm, shining medium brown with very narrow fragile edges, scales on upper part of stipe smaller. Largest pinnae 10–16 cm long; pinnules to 2.5 cm × 7 mm, only a few free near bases of largest pinnae, rest connected by a narrow wing along pinna-rachis; largest pinnules, where fertile, lobed ½ way to costa, where sterile less deeply. Sori in a single row on each side of costae of pinnules; indusium firm and dark, breaking irregularly at maturity. Scales on costae bullate with flexuous hair-tips 1 mm or more long.

Only known from Mt Kinabalu, in Leptospermum — Dacrydium forest on ridges at 8000–10,000 feet.

4. **Cyathea oosora** Holtt., Kew Bull. 16(1962) 59. F.M. 101.

Stipe 50 cm or more long, warty near base; pneumathodes 14–20 mm long in an almost continuous line, scales not seen. Largest pinnae 60 cm long; pinnules to 9 × 2 cm, sessile or nearly so, lobed almost to costa, lobes rigid, crenate; costules 3½–4 mm apart, veins 9–10 pairs. Sori near costules; indusium firm, brown, at first ovoid with a small apical aperture, later breaking irregularly. Pinna-rachis bearing a few narrow brown scales 3–4 mm long; costae densely scaly, scales uniformly brown, lower ones elongate, grading to hair-pointed bullate scales distally and on costules.

Distribution: Mt Kinabalu at 7000–10,000 ft; also from Mt Rante Mario in S. W. Celebes at 10,000 ft. The Celebes specimens differ in having paler scales on costae.

5. *Cyathea loheri* Christ, Bull. Herb. Boiss. II, 6(1906) 1007. F.M. 104. — *C. korthalsii* sensu C. Chr., Gard. Bull. S. S. 7(1934) 222, non Mett.

Trunk to 10 m tall. Stipe short; scales to $25 \times 1\frac{1}{2}$ –3 mm, pale, firm, their fragile edges bearing scattered long setae; pneumatodes to 11 mm long. Lower pinnae gradually smaller, lowest 7 cm long, longest 40 cm or more; largest pinnules $7\frac{1}{2}$ – $9\frac{1}{2}$ × $1\frac{1}{2}$ –2 cm, sessile, short-acuminate, lowest 1–4 segments ± contracted at base, rest of pinnule lobed almost to costa, segments deeply crenate where fertile; costules $3\frac{1}{2}$ –4 mm apart, veins 10–12 pairs. Sori near costules; indusium firm, shining brown, almost covering sorus to maturity but open on side remote from costule, breaking when old. Pinna-rachis at first densely scaly, larger scales pale with some dark setae; scales at base of costae light brown with marginal hairs or setae, grading to bullate scales distally and on costules.

Distribution: Mt Kinabalu, near streams in forest in deep valleys at 7000–9000 ft; Philippines (Luzon, Negros, Mindanao); Taiwan.

This species apparently occurs at lower altitudes in the Philippines than on Mt Kinabalu. Young plants found by me had long stipes, the lower pinnae not greatly reduced. The stipe-scales are distinctive.

6. *Cyathea incisoserrata* Copel., Philip. Journ. Sci. 6C(1911) 361. F.M. 113, fig. 18. — *Alsophila latebrosa* var. *ornata* Ridl., Journ. Mal. Br. R. Asiat. Soc. 4 (1926) 8.

Trunk to about 4 m tall; stipe to 85 cm, warty or with short conical spines at the base; scales sparse, to 10×1 mm, dark with narrow quickly abraded fragile edges; pneumatodes in a double row on each side of stipe, almost continuous. Lower pinnae slightly reduced, longest 70 cm long; pinnules commonly $10 \times 2\frac{1}{2}$ cm, to $12 \times 3\frac{1}{2}$ cm, sessile, deeply lobed, lobes crenate and separated by wide sinuses; costules $4\frac{1}{2}$ – $5\frac{1}{2}$ mm apart, veins 12–15 pairs. Sori near costules; indusium very small, on one side of base of sorus, covered by sporangia; paraphyses longer than sporangia, flat and 2–3 cells wide at base. Lower surface of pinna-rachis pale green, smooth; scales near bases of costae elongate, flat, entire, grading to bullate scales distally and on costules.

Distribution: lowland forest in Malaya and Sarawak. This is very near *C. latebrosa* (no. 8) but seems to be constantly distinct.

7. *Cyathea borneensis* Copel., Philip. Journ. Sci. 6C(1911) 135. F.M. 110, — *C. obtusata* Rosenst., Med. Rijksherbar. no. 31(1917)1; Holttum, Rev. Fl. Mal. 2 (1955) 121.

Trunk to 2 m or more tall; stipes c. 25 cm, dark and warty at base, scales to 15×1 mm, dark, glossy, with narrow fragile edges; pneumatodes 12–18 mm long. Lower pinnae rather irregularly reduced, lowest c. 10 cm long, longest 60 cm; largest pinnules 8–10 × 1.7–2.2 cm, deeply lobed, lobes almost entire; costules $3\frac{1}{2}$ –5 mm apart, veins to 10 pairs. Sori near costules; indusium rather thin, on costular side, pressed against costule at maturity of sorus; paraphyses short. Pinna-rachis green, ± suffused with purple, bearing crisped hairs distally on lower surface; scales on costae dark, entire, flat or with bullate base, grading to dark bullate scales distally and on costules.

Distribution: Sarawak and Sabah, in lowland forest and to 3500 ft, but not recorded for Mt Kinabalu; Malaya and Peninsular Thailand.

8. **Cyathea latebrosa** (Hook.) Copel., Philip. Journ. Sci. 4C(1909) 52. Gard. Bull. S. S. 7(1934) 195, 198, 222. F.M. 115. — *Alsophila latebrosa* Hook., Spec. Fil. 1 (1844) 37.

Similar to *C. incisoserrata* (no. 6) but smaller, with smaller pinnules having costules 3–4 mm apart and narrow sinuses between the lobes; pneumatodes on stipe in a single row on each side.

Distribution: throughout Borneo; Sumatra, Malaya, Thailand to Hainan, in forest or on edges of forest, in low country and to 4500 ft.

SUBG. *Alsophila* SECT. *Gymnosphaera*

1. Base of stipe bearing reduced pinnae, widely separated from normal pinnae:
 2. Small basal pinnae with many narrow persistent segments, green when young, soon turning brown 9. *C. ramispina*
 2. Small basal pinnae stiffly spreading, with few slightly-lobed leaflets, spine-like when old 10. *C. recommitata*
 - .1. Base of stipe lacking reduced pinnae 11. *C. glabra*.
9. **Cyathea ramispina** (Hook.) Copel., Philip. Journ. Sci. 4C(1909) 36. Gard. Bull. S. S. 7(1934) 200, 222. F.M. 117. — *Alsophila ramispina* Hook., Syn. Fil. (1866) 42.

Trunk rather slender, to 2 m tall, persistently covered with the finely divided basal pinnae which remain attached to the old leaf-bases (the youngest ones green and covering the apex of the trunk). Stipe dark, almost covered with small scales, basal scales very dark, glossy, to $10 \times 1\frac{1}{2}$ mm with pale fragile edges. Normal pinnae to 45 cm long; pinnules slightly dimorphous (fertile smaller), lowest with stalks 2–3 mm long, largest $7-9 \times 1\frac{1}{2}-2$ cm, lobed to about 2 mm from costa, lobes slightly crenate; costules $4-4\frac{1}{2}$ mm apart, veins to 8 pairs, usually all simple. Sori without indusia, distal ones close to costule, lower ones more distant from it. Scales on costae and costules narrow, dark, glossy with pale edges, grading to pale bullate scales.

Distribution: Sarawak and Sabah, in ridge forest at 6000–7000 ft on Mt Kinabalu; at 3000–4500 ft in Sarawak; also at 500 ft on a sandstone hillside in Tawao, Sabah.

10. **Cyathea recommitata** Copel., Philip. Journ. Sci. 4C(1909) 36. Gard. Bull. S. S. 7(1934) 198, 220. Holtum, Rev. Fl. Mal. 2 (1955) 125. F.M. 118, fig. 19a, b, 20d.

Habit of *C. ramispina* but basal small pinnae not so closely placed, rigidly spreading on each side of base of stipe, bearing few less deeply lobed leaflets which often become detached so that the reduced pinnae are like stout spines when old. Largest pinnae 40 cm long; pinnules rather strongly dimorphous, sterile to 1.6 cm wide with costules $4-4\frac{1}{2}$ mm apart, fertile 6–12 mm wide with closer costules.

Distribution: Borneo, Malaya, central and southern Sumatra; in forest, usually at lower altitudes than *C. ramispina*, on Mt Kinabalu at 4500 ft; also occurring in several parts of Borneo in lowland swamp forest on sandy ground.

11. ***Cyathea glabra*** (Bl.) Copel., Philip. Journ. Sci. 4C(1909) 35. Holttum, Rev. Fl. Mal. 2(1955) 127. F.M. 120. — *Gymnosphaera glabra* Bl., Enum, Pl. Jav. (1828) 242. — *Alsophila vexans* Cesati, Atti Acad. Napol. 7, no. 8(1876) 4. — *Cyathea vexans* (Ces.) C. Chr., Gard. Bull. S. S. 7(1934) 218.

Trunk rather slender; stipes very dark; basal scales dark, glossy with pale fragile edges. Lower pinnae sometimes much reduced but not remote from rest; largest pinnae 45–55 cm long; largest pinnules 9–12 × 1½–2 cm, lowest on stalks 2–4 mm long, edges crenate to slightly lobed, not or little dimorphous; costules 4–5 mm apart; veins 3–5 pairs, simple. Sori without indusium. Scales on costae few, narrow, dark with pale edges which often bear a few dark setae; no bullate scales.

Distribution: West Java, Sumatra, Malaya, Borneo; in lowland swamp forest and in mountain forest to 5000 ft. There has been much confusion in the use of the specific name *glabra*, and there are other synonyms.

SUBG. *Sphaeropteris* SECT. *Sphaeropteris*

1. Free tertiary leaflets few:
 2. Stipe minutely warty at base; lower surfaces of costae copiously hairy throughout; indusia present 12. *C. leucotricha*
 2. Stipe strongly spiny at base; lower surface of costae bearing a few hairs distally; no indusia 13. *C. contaminans*
 1. Free tertiary leaflets present on all pinnules 14. *C. tripinnata*

12. ***Cyathea leucotricha*** Christ, Ann. Jard. Bot. Btzg 20(1905) 135. F.M. 127.

Height of trunk not recorded. Stipe 50 cm, minutely warty; basal scales early caducous, dark brown with concolorous marginal setae. Largest pinnae 60 cm long; largest pinnules 9–12 × 1½–2 cm, 1–3 basal segments free or nearly so, rest of pinnule lobed almost to costa, lobes crenate; costules 4–5 mm apart, veins 10–12 pairs. Sori nearer to costule than to edge, indusiate; indusium pale, thin, breaking irregularly at maturity. Pinna-rachis glabrescent; costae and costules bearing many stiff spreading pale hairs on lower surface; a few narrow pale scales with dark setae near bases of costae.

Distribution: in lowland forest, recorded for several widely-spaced localities in Sarawak, Brunei and Kalimantan. This species is interesting because very few others in this section have indusia. More information about it would be welcome.

13. ***Cyathea contaminans*** (Hook.) Copel., Philip. Journ. Sci. 4C(1909) 60. Gard. Bull. 7(1934) 196, 222. Holttum, Rev. Fl. Mal. 2(1955) 119. F.M. 135. — *Alsophila contaminans* Hook., Spec. Fil. 1(1844) 52.

Trunk often very tall, much thickened by adventitious roots at base, when old showing leaf-scars on upper part. Stipe to 100 cm long, pale glaucous, purplish towards base which is strongly spiny and covered with pale brown scales varying in size up to 45 × 3 mm, very thin with short dark marginal setae; main rachis bearing many short spines throughout. Lowest pinnae somewhat reduced with stalks to 10 cm long; largest pinnae 60 cm; pinnules to 15 × 3 cm, often smaller,

lowest distinctly stalked, largest with 1–2 pairs basal segments ± free, rest lobed almost to costa, lobes crenate, glaucous beneath; costules 4–4½ mm apart, veins commonly 12 pairs. Sori near costules, no indusia. Lower surface of costae bearing at first scattered narrow pale setiferous scales which soon fall; costular scales small, ovate, pale-fringed, soon caducous; a few hairs pairs present on lower surface of costae and costules near pinna-apex, variable in number; on Mt Kinabalu erect hairs may also be presented on lower surface of veins.

Distribution: throughout Malesia, in clearings and open places in forest, especially near streams, at 1000–5000 ft, often abundant. This is now by far the most conspicuous tree-fern at lower levels in Mt Kinabalu National Park.

14. *Cyathea tripinnata* Copel., Philip. Journ. Sci. IC, Suppl. 4 (1906) 251. Gard. Bull. S. S. 7(1934) 198, 222. Holttum, Rev. Fl. Mal. 2(1955) 120. F.M. 140.

Trunk 4–5 m tall; stipes to at least 40 cm, dark, bearing scattered sharp spines 1–3 mm long, covered almost throughout by a felt of very small setiferous scales, basal scales to 25 × 1 mm, thin and soft, matted together. Lowest pinnae 20–30 cm long, largest 60 cm; pinnules 9–14 × 1½–2½ cm, fully pinnate; tertiary leaflets to 15 × 3½ mm, largest deeply lobed at base, lower ones distinctly stalked; veins to 9 pairs, those in free basal lobes pinnate. Sori near midribs of tertiary leaflets, covered at maturity by overlapping thin pale scales. Lower surfaces of pinna-rachis, costae and costules bearing minute pale fringed scales.

Distribution: Pulau Tioman, Sabah, Philippines (Luzon to Mindanao), Amboina. The specimens from West Java which I formerly identified with this species appear to be distinct, matching recent collections from southern Sumatra; these will be described elsewhere as a new species of subsect. *Fourniera*.

SUBG. *Sphaeropteris* SECT. *Schizocaena*

1. Fronds simply pinnate, pinnae entire or crenate-serrate:
 2. Apex of frond a deltoid deeply lobed lamina; pinnae sessile; basal veins anastomosing 15. *C. capitata*
 2. Apex of frond pinna-like; pinnae usually stalked; veins free:
 3. Pinnae not over 1.5 cm wide, stalks to 12 mm long; sori in 1–2 rows on each side of costa, fully indusiate 16. *C. angustipinna*
 3. Pinnae 2–4 cm wide, stalked or not; sori on fully fertile pinnae in more than 2 rows, indusiate or not:
 4. Pinnae not long-acuminate, upper usually sessile 17. *C. moluccana*
 4. Pinnae long-acuminate, all stalked 18. *C. arthropoda*
1. Fronds simply pinnate with deeply lobed pinnae, or bipinnate:
 5. Fronds simply pinnate with deeply lobed pinnae, or largest pinnae sometimes with free pinnules at their base:
 6. Pinnae commonly 25 cm long; no long pale hairs on lower surface of rachis 19. *C. alternans*
 6. Pinnae sometimes shorter; main rachis bearing long pale hairs on lower surface 20. *C. trichophora*

5. Fronds amply bipinnate:
7. Sori indusiate (indusium sometimes reduced to a disc hidden by sorus):
8. Basal pinnules of middle pinnae with stalks to at least 4 mm long:
9. Pinnules lobed less than $\frac{1}{2}$ way to costa; no free basal segments 21. *C. stipitipinnula*
9. Pinnules lobed to 1–2 mm from costa; larger pinnules with 1–2 free basal segments 22. *C. assimilis*
8. Basal pinnules sessile or nearly so;
10. Indusium a disc hidden by sorus; basal pinna-lobes not free 23. *C. discophora*
10. Indusium complete, covering sorus to maturity 24. *C. megalosora*
7. Sori without indusia:
11. Long spreading hairs abundant on lower surface of rachis and/or pinna-rachis, often also on costae:
12. Costules and veins bearing hairs like those of costa on lower surface:
13. Pinnules lobed $\frac{2}{3}$ – $\frac{3}{4}$ towards costa; costules 4 mm or more apart 25. *C. trichodesma*
13. Pinnules lobed to within 1 mm from costa; costules 3– $3\frac{1}{2}$ mm apart 26. *C. wallacei*
12. Costules and veins lacking hairs on lower surface 20. *C. trichophora*
11. Long spreading hairs lacking on lower surface of rachises:
14. Largest pinnules with a free segment at base; pinnules on stalks to 4 mm or more long 27. *C. polypoda*
14. Largest pinnae lacking free basal segment, almost sessile:
15. Bullate scales lacking on costae and costules; pinnules lobed to less than 1 mm from costa 28. *C. agatheti*
15. Bullate scales present on costae and costules; pinnules less deeply lobed 29. *C. squamulata*

15. ***Cyathea capitata*** Copel., Philip. Journ. Sci. 12C(1917) 49. Gard. Bull. S. S. 7(1934) 201, 218. F.M. 142.

Trunk 1–3 m tall; stipe dark, to at least 40 cm long; basal scales brown, firm, to 25×3 –4 mm, edges bearing concolorous setae. Apex of frond broadly deltoid and deeply lobed, grading into upper pinnae; pinnae to 40 pairs, jointed to rachis, largest 15 – 19×2 –3 cm, edges entire except near apex, base truncate to cordate; veins in pinnate groups of c. 3 pairs, outer members of each group anastomosing with those of adjacent groups. Sori usually in 2 rows on each side of the costa of a pinna; indusium thin, completely covering young sorus, breaking when old.

Distribution: Sarawak (Mt Murud), Sabah (Mt Kinabalu), in wet ground near streams in forest at 4500–6000 ft.

16. Cyathea angustipinna Holtt., Kew Bull. 16(1962) 52. F.M. 143.

Trunk to at least 50 cm tall; stipe c. 30 cm, basal scales pale, firm, to $20 \times 1\frac{1}{2}$ mm, marginal setae dark. Pinnae c. 18 pairs, to 12 cm long, sterile to 1.6 cm wide, fertile 1.0–1.2 cm, base narrowly cuneate, stalks to 12 mm long, edges entire except near apex; veins in groups of 3, basal one attached separately to costa, free. Sori in 2 rather uneven rows on each side of costa, indusiate as in *C. capitata*.

Distribution: known only from 2 collections on Mt Dulit, Sarawak, on sandy bank of stream near waterfall, in forest, at 4000 ft.

17. Cyathea moluccana R. Br. in Desv., Mem. Soc. Linn. Paris 6(1827) 322. F.M. 143. — *C. kinabaluensis* Copel., Philip. Journ. Sci. 12C(1917) 50. C. Chr., Gard. Bull. S. S. 7(1934) 218. — *C. brunonis* Hook., Gen. Fil. (1838) t.2. Holttum, Rev. Fl. Mal. 2(1955) 117.

Trunk to 50 cm tall; stipe 20–30 cm, basal scales medium brown, 15–30 x $\frac{1}{2}$ –3 mm, edges with concolorous setae. Leafy part of frond to 150 cm or more long; apical lamina a pinna like the rest; pinnae jointed to rachis, stalked or the upper ones sessile, 12–28 x 2–4 cm, base broadly cuneate, edges entire except for short-acuminated crenate apex; veins as in *C. angustipinna*, but the middle vein of each group forked once or twice. Sori in 1–3 rows on each side of costa, commonly 4–6 on each vein-group, indusium as *C. capitata* or in some cases only forming a disc which is hidden by sorus.

Distribution: Central Sumatra, Malaya, Lingga, Borneo (excluding south and south-west), South & Central Celebes, Moluccas (Ceram, Amboina), in forest, low country to 3000 ft.

Copeland in 1917 described three exindusiate species from Mt Kinabalu, *C. kinabaluensis*, *C. pseudobrunonis* and *C. fuscopaleata*, distinguishing them by size and colour of stipe-scales, but I cannot see clear distinctions between them, and none are totally without indusia. See note under *C. alternans*.

18. Cyathea arthropoda Copel., Philip. Journ. Sci. 6C(1911) 134, t.13. F.M. 143.

Habit of *C. moluccana*, differing: all pinnae stalked, stalks of upper ones 5 mm, of lower ones 12–15 mm; shape of pinnae narrowly elliptical (sides not parallel as in *C. moluccana*) with a caudate apex to 4 cm long; indusium a narrow irregular ring hidden by sorus.

Distribution: Sarawak, Bongo Range. The shape of pinnae appear to distinguish this from *C. moluccana*, but the latter is variable and needs more study in Borneo.

19. Cyathea alternans (Hook.) Presl, Abh. K. Böhm. Ges. Wiss. V, 5(1848) 347. Gard. Bull. S. S. 7(1934) 219. F.M. 145 — *Hemitelia alternans* Hook., Ic. Pl. 7(1844) t. 622.

Trunk usually less than 2 m tall; stipe to 60 cm, dark, basal scales to 30×2 mm. Pinnae jointed to rachis, lowest sometimes reduced, largest commonly 25×4 –5 cm, in some cases to 40×9 cm, deeply lobed throughout (lobes entire, rounded at apex) or with few to many of the lobes acute at apex and separately joined by their contracted bases to axis of pinna, rarely 1–2 basal ones as quite free pinnules; veins varying in number according to size of pinna-lobes. Sori usually in one row on each side of costules of a pinna-lobe; indusium sometimes

completely covering sorus to maturity, more often forming an irregular disc round base of sorus. Scales on lower surface of pinna-midrib and costules of lobes usually sparse, narrow, setiferous; bullate scales sometimes present on costules, sometimes also thick pale hairs.

Distribution: Sumatra, Malaya, Borneo, in forest, 1000–4000 ft.

The variable plants here included are always found growing in association with *C. moluccana*, and are in several respects intermediate between *C. moluccana* and *C. squamulata* (no. 29). The latter is fully bipinnate and quite exindusiate. If *C. alternans* does in fact represent a series of hybrids, the existence of plants otherwise almost indistinguishable from *C. moluccana* could represent extreme cases of introgressive hybridization. Experimental study of these plants is desirable.

20. ***Cyathea trichophora*** Copel., Philip. Journ. Sci. 6C(1911) 363. F.M. 151.
— *C. elliptica* Copel., Philip. Journ. Sci. 12C(1917) 51. F.M. 146.

Trunk to 50 cm tall. Stipe 25–50 cm, ± persistently scaly throughout, scales to 20×3 mm, light brown, glossy; main rachis bearing narrow setiferous scales and also hairs 2 mm long on lower surface. Lowest pinnae sometimes deflexed, largest 30–45 cm long; largest pinnules $3-6\frac{1}{2} \times 1.2-1.4$ cm, lobed $\frac{1}{2}$ way to costa; costules $3\frac{1}{2}-4$ mm apart; veins 3–5 pairs. Sori medial, exindusiate. Hairs sometimes present on lower surface of pinna-rachis and costae, not on veins; bullate scales on costules.

Distribution: Sarawak, Sabah, Philippines, in forest, lowlands to 4000 ft.

The type of *C. trichophora* was found in Luzon, that of *C. elliptica* on Mt Kinabalu. Specimens on which Copeland based six other names are also here included. The differences between them are slight. Small plants may have few free pinnules.

21. ***Cyathea stipitipinnula*** Holtt., Kew Bull. 16(1962) 62. F.M. 147.

Stipe to more than 30 cm long, persistently scaly; scales to 25×3 mm, glossy brown with paler edge bearing dark setae; minute scales also present; main rachis glabrescent on lower surface. Pinnae to 45 cm long; pinnules to 6.5×1.2 cm, lobed less than $\frac{1}{2}$ way to costa, coriaceous, lowest pinnules with cordate bases and stalks to 4 mm long; costules $3\frac{1}{2}-4$ mm apart; veins 3–4 pairs, thick. Sori usually 3 to each pinnule-lobe, medial; indusium pale, firm, covering sorus to maturity. Scales near bases of costae light brown, ovate-acute, flat, with crisped marginal hairs or short setae, grading to light brown bullate scales on costules and veins.

Distribution: Mt Kinabalu, Marei Parei ridge, in open places, 4000–5000 ft.

22. ***Cyathea assimilis*** Hook., Syn. Fil. (1865) 24. F.M. 150.

Stipes to 65 cm long, finely warty, persistently scaly near base; scales firm, $15-20 \times 1-2$ mm. Lamina to almost 200 cm long; pinnae ± jointed to rachis, lower ones with stalks to 4 cm, largest 55 cm long; largest pinnules $8-9 \times 2\frac{1}{2}$ cm, lowest with stalks 4–8 mm, basal 1–2 segments of larger pinnules free, rest lobed to 1–2 mm from costa, lobes firm, crenate; costules 5–7 mm apart, veins 8–10 pairs. Sori medial; indusium pale, thin, covering sorus to maturity. Pinna-rachis glabrous beneath; costa with narrow setiferous scales at base grading to bullate scales distally and on costules; no hairs on lower surfaces of axes of frond.

Distribution: Southern Sumatra, Sarawak, at 1000–7000 ft. Plants of ridge forest on sandstone (Mt Dulit) have darker and more rigid fronds, sometimes smaller than above described.

23. **Cyathea discophora** Holtt., Kew Bull. 16(1962) 54. F.M. 148.

Stipe persistently scaly near base; scales pale, to 25×2 mm, edges with short dark setae; rachis glabrescent, finely and sparsely warty beneath. Pinnae to 50 cm long, pinnules rather widely spaced, sessile; largest pinnules $8 \times 1\frac{1}{2}$ cm, rather thin, lobed $\frac{2}{3}$ towards costa except at base, lowest segment not free; costules $4-4\frac{1}{2}$ mm apart; veins 6–7 pairs. Sori medial; indusium a thin brown disc of irregular shape covered by ripe sorus. Costae rather densely scaly, basal scales pale, flat, elongate with stiff pale marginal hairs, grading to rather large pale acuminate bullate scales distally and on costules; a few long hairs on costa near apex of pinnule and on costules.

Distribution: only known from the type, at 8000 ft on Mt Kinabalu, in open place in forest. This is intermediate between *C. megalosora* and *C. squamulata*.

24. **Cyathea megalosora** Copel., Philip. Journ. Sci. 12C(1917) 54. Gard. Bull. S. S. 7(1934) 221. F.M. 148.

Trunk to at least 2 m tall. Stipe c. 30 cm long, densely scaly; scales thin, pale, somewhat crisped, to $25 \times 1\frac{1}{2}$ mm, edges sparsely setose. Lowest pinna 20 cm, largest 35 cm long; pinnules to 6×1.2 cm, almost sessile, lowest 1–2 segments free, rest of pinnule lobed almost to costa; costules 4–5 mm apart, veins 5–7 pairs; lamina-segments very firm, crenate. Sori medial; indusium firm, covering sorus to maturity. Pinna-rachis persistently densely scaly on lower surface, scales long, pale, bases of smaller ones bullate; costae densely scaly, scales elongate, not setiferous; many long hairs towards apex of costa; similar hairs on costules and a few on veins; long pale hairs also on upper surface of costules and veins.

Distribution: Mt Kinabalu, in mossy forest on ridges at 7000–10000 ft; plants at highest altitudes have smaller fronds, with pinnae to $10\frac{1}{2} \times 2\frac{1}{2}$ cm, free pinnules c. 5 pairs, lobed only $\frac{1}{2}$ way to costa.

25. **Cyathea trichodesma** (Scort.) Copel., Philip. Journ. Sci. 4C(1909) 55. F.M. 150. — *Alsophila trichodesma* Scort. in Bedd., Journ. Bot. 25(1887) 321. — *C. burbridgei* sensu C. Chr., Gard. Bull. S. S. 7(1934) 222; sensu Holttum, Rev. Fl. Mal. 2(1955) 124, non (Bak.) Copel.

Trunk to $4\frac{1}{2}$ m tall. Stipe densely scaly near base; scales medium to light brown, firm, to 25×2 mm, closely setose. Pinnae to 60 cm long; pinnules in Malaya $9-11 \times 1\frac{1}{2}-2$ cm, on Mt Kinabalu to $7 \times 1\frac{1}{2}$ cm, nearly sessile, lobed to 2 mm from costa, no free basal segments; costules $4\frac{1}{2}-5$ mm apart; veins 6–8 pairs. Sori medial, often confluent at maturity, no indusia. Pinna-rachis, costae, costules and veins bearing many pale erect hairs 1–2 mm long on lower surface; scales on costae and costules sparse, pale, some bullate, most with dark setae; in Malaya hairs present on upper surface of costules and veins.

Distribution: Malaya, Sarawak, Sabah, in lowland forest; to 5000 ft on Mt Kinabalu. The Kinabalu specimens are perhaps smaller than those in Malaya owing to altitude.

26. **Cyathea wallacei** (Kuhn) Copel., Philip. Journ. Sci. 4C(1909) 48. F.M. 151. — *Alsophila wallacei* Kuhn, Linnaea 36 (1869) 153. — *A. burbridgei* Bak., Journ. Bot. 17(1879) 38; not *Cyathea burbridgei* sensu C. Chr., Gard. Bull. S. S. 7 (1934) 222, which is *C. trichodesma*.

Stipe 30 cm or more long, pale and smooth above base; basal scales to 15×2 mm, pale brown; main rachis finely hairy on distal part of lower surface. Largest pinnae 38 cm long; pinnules to 6.5×1.3 cm, sessile, lobed to within 1 mm from costa; costules $3-3\frac{1}{2}$ mm apart; veins 4–6 pairs, mostly simple. Sori medial, no indusia. Lower surface of pinna-rachis, costae, costules and veins bearing pale hairs 1 mm long; pale bullate scales on costae and costules; long hairs present on upper surface of costae and costules.

Distribution: Sarawak, Sabah, in lowland forest (including Bako National Park, near Kuching). This differs from *C. trichodesma* in more deeply lobed pinnules and closer costules. It has the aspect of a stunted member of sect. *Sphaeropteris* but has the venation of sect. *Schizocaena*.

27. **Cyathea polypoda** Bak., Trans. Linn. Soc. II Bot. 4(1894) 250. F.M. 151. — *C. kemberangana* Copel., Philip. Journ. Sci. 12C(1917) 52. Gard. Bull. S. S. 7(1934) 200, 219. — *C. ampla* sensu Holtt., Rev. Fl. Mal. 2(1955) 125, non Copel.

Trunk to 3 m tall; small branches frequent on its lower part. Stipe to 80 cm, green; basal scales medium brown, firm, to 30 c 2 mm, setae concolorous; rachis glabrescent on lower surface. Pinnae to 60 cm long; lower ones long-stalked; largest pinnules $8\frac{1}{2}-11 \times 2.0-2.7$ cm, thick and rigid when dry, all stalked, stalks of lowest 9 mm; basal 1–2 segments of largest pinnules free, rest of pinnule lobed to 1–2 mm from costa; costules $4\frac{1}{2}-5\frac{1}{2}$ mm apart; veins 7–9 pairs. Sori inframedial, no indusia. Small dark or brown setiferous scales near bases of costae; bullate scales, often setiferous, on costules, all early caducous.

Distribution: Malaya, Borneo, Philippines (Panay, Mindanao); in open places on ridge-crests and summits, 2000–7000 ft; specimens from the higher altitudes very tough. Baker described the type of this species as indusiate; the "indusia" which he saw were bullate scales partly covering young sori.

28. **Cyathea agatheti** Holtt., Kew Bull. 16(1962) 51. F.M. 152.

Trunk hardly 5 cm tall. Stipe 35–75 cm long, dark towards base, rest smooth, green; basal scales $10 \times 2-2\frac{1}{2}$ mm, light brown with dark setae on pale edge. Lamina of frond 50–60 cm long; pinnae jointed to rachis, largest 18–25 cm long; pinnules to $3\frac{1}{2} \times 1$ cm, lobed to within 1 mm from costa, lowest with stalks 1 mm long; costules 3 mm apart; veins 4–5 pairs, simple. Sori medial, no indusia. Lower surface of costae bearing scattered pale hairs, few hairs on costules; scales few, not bullate; upper surface of costae, costules and veins bearing long hairs.

Distribution: only known from original collection, W. Kutai, Kalimantan, in Agathis forest on water-logged white sand, at 2000 ft.

29. **Cyathea squamulata** (Bl.) Copel., Philip. Journ. Sci. 4C(1909) 37. C. Chr. in Gard. Bull. S. S. 7(1934) 219 excl. syn. *C. elliptica* Copel. Holtt., Rev. Fl. Mal. 2(1955) 122, fig. 49. F.M. 152.

Trunk to 2 m tall. Stipe 40–60 cm, persistently scaly throughout (main rachis sometimes also); scales firm, medium brown with dark setae, to $30 \times 2-3$ mm. Lowest pinnae somewhat reduced, variable, largest 50 cm long; largest pinnules $8-10 \times 1\frac{1}{2}-2$ cm, rather thin with almost entire lobes, lobed $\frac{1}{2}-\frac{2}{3}$ towards costa (more deeply only in largest); costules $3\frac{1}{2}-4\frac{1}{2}$ mm apart; veins 6–9 pairs, simple in smaller pinnules, forked in larger. Sori a little inframedial, no indusia; pale paraphyses longer than sporangia. Pinna-rachis glabrescent beneath, finely warty; costae with flat brown setiferous scales at base, grading to bullate distally and on costules; no hairs on lower surface of costules, a few on upper surface.

Distribution: Sumatra, Java, Malaya, Borneo, Sulu Archipelago, in lowland forest; in Malaya rarely above 3500 ft; specimens from higher altitudes (to 7000 ft) on Mt Kinabalu are small, with densely scaly rachis.

Addendum: A new species from Mt Kinabalu

In 1966 Mr E. F. Allen collected a small plant of a tree fern at an altitude of 10,000 feet on Mt Kinabalu, and brought it to his home, near Ipswich in England, where he successfully cultivated it. It flourishes in the open air in summer, but in the winter needs the protection of a cool greenhouse. This plant has now produced a fertile frond, and proves to be distinct from any previously known species.

The key to the species of subg. *Alsophila* sect. *Alsophila* needs to be modified at indentation 5 as follows, to accommodate the new species and to indicate its distinctive characters.

Young sorus completely covered by indusium which breaks at maturity, leaving the exposed sporangia surrounded by an irregular cup *C. oosora*

Indusium hood-shaped, attached only on the side towards the costule, not quite covering sorus at maturity:

Basal scales on stipe firm, pale, to 25×3 mm; stipe short, its pneumatodes to 11 mm long; several pairs of lower pinnae gradually reduced, lowest 7 cm long; pinnules to $9\frac{1}{2}$ cm long, less than 2 cm wide; costules $3\frac{1}{2}-4$ mm apart; small scales mostly lacking rigid marginal setae, bullate scales abundant on costae and costules *C. loheri*

Basal scales of stipe light brown, thin, to $10 \times 1\frac{1}{2}$ mm; stipe to 50 cm long its pneumatodes 3 mm long, well spaced; lower pinnae little reduced; fertile pinnules 7×2.2 cm, costules $4\frac{1}{2}-5$ mm apart; nearly all small scales bearing several rigid setae; bullate scales few, often setiferous *C. brachyphylla*

Cyathea brachyphylla Holttum, sp. nov.

C. loheri affinis, differt: frondibus minoribus; stipite 50 cm longo, basi paleis tenuibus usque $10 \times 1\frac{1}{2}$ mm vestita, sursum paleis minutis plerisque copiose setiferis praedito; pneumatodiis 3 mm longis, valde dissitis; pinnis inferioribus paulo reductis; pinnis maximis 33 cm longis; pinnulis usque 7×2.2 cm; costulis $4\frac{1}{2}-5$ mm inter se distantibus; paleis rhachidum costarumque fere omnibus setiferis, paleis bullatis paucis distalibus etiam plerisque setiferis.

Type: cult. E. F. Allen, Ipswich, England, origin Mt Kinabalu, alt. 10,000 ft (holotype K; isotype SING).

Mr Allen reports that he saw plants with trunks up to 8 feet (240 cm) tall. They were growing in deep soil in a sheltered place, not on the crest of the ridge where *Cyathea havilandii* is abundant at about the same altitude.

As indicated in the revised part of the key, the new species is related to *C. loheri* in the form of its sori, but differs in its smaller size with fronds of a different shape, and in the scales of all parts of the frond. The other two species of *Cyathea* which have previously been found near 10,000 feet altitude (*C. havilandii* and *C. oosora*) have sori of a different structure; careful examination with a hand lens is necessary to distinguish the difference.